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Kunstmann

(54) **EXERCISE MACHINE WITH CONTROLLED MOTION AND USER FORCE MATCHING RESISTANCE**

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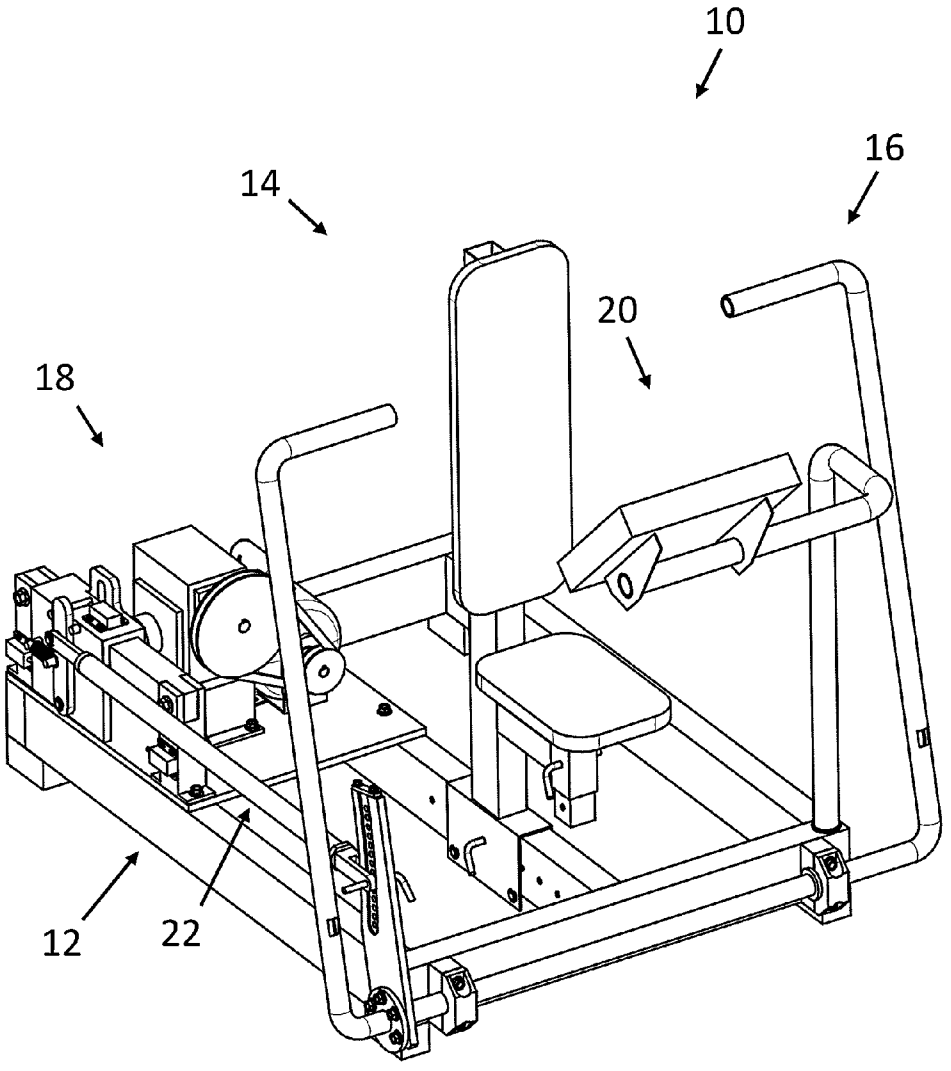
(57) **ABSTRACT**

An exercise machine with controlled motion and user force matching resistance. The machine includes a frame to which is rigidly mounted a motor driven reciprocating drive. A user engageable arm is pivotally mounted to the frame. The reciprocating drive is connected to the arm by a rigid connecting rod. The reciprocating drive drives the arm through a predetermined stroke following a pre-determined velocity profile. The user performs the exercise by applying force to the arm. The arm applies a generally equal counterforce to the force applied by the user. The pre-determined motion of the arm is generally independent of the force applied by the user. The stroke of the arm has a fixed fully contracted position and a user adjustable fully extended position. Adjustments to the fully extended position are made by changing the location of the joint between the connecting rod and the arm. Motion of the arm starts upon application of force applied by the user, and stops when the user force is removed.



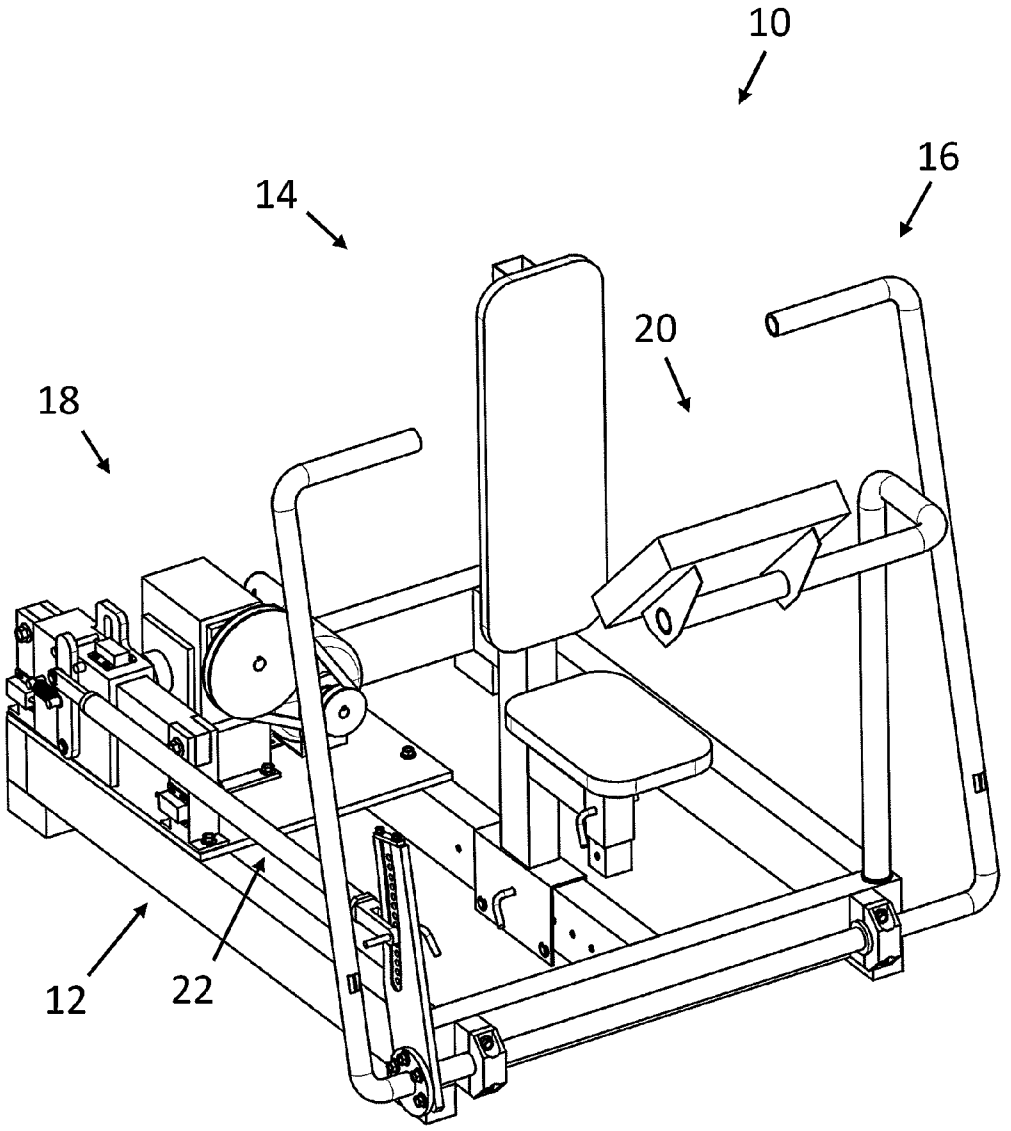


Fig. 1

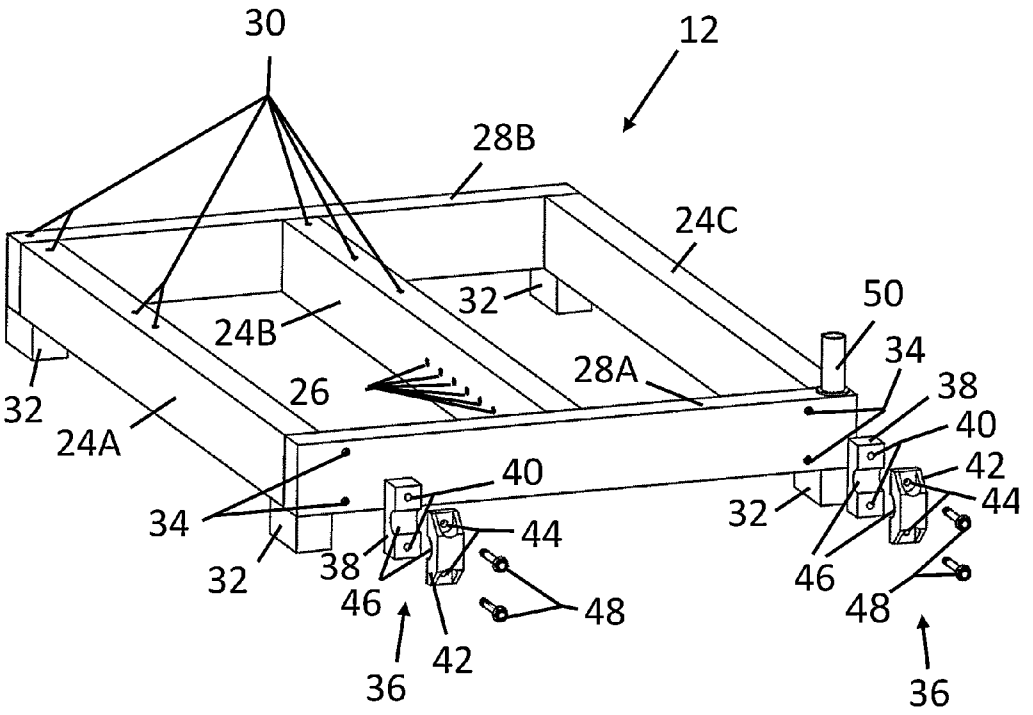

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Fig. 2

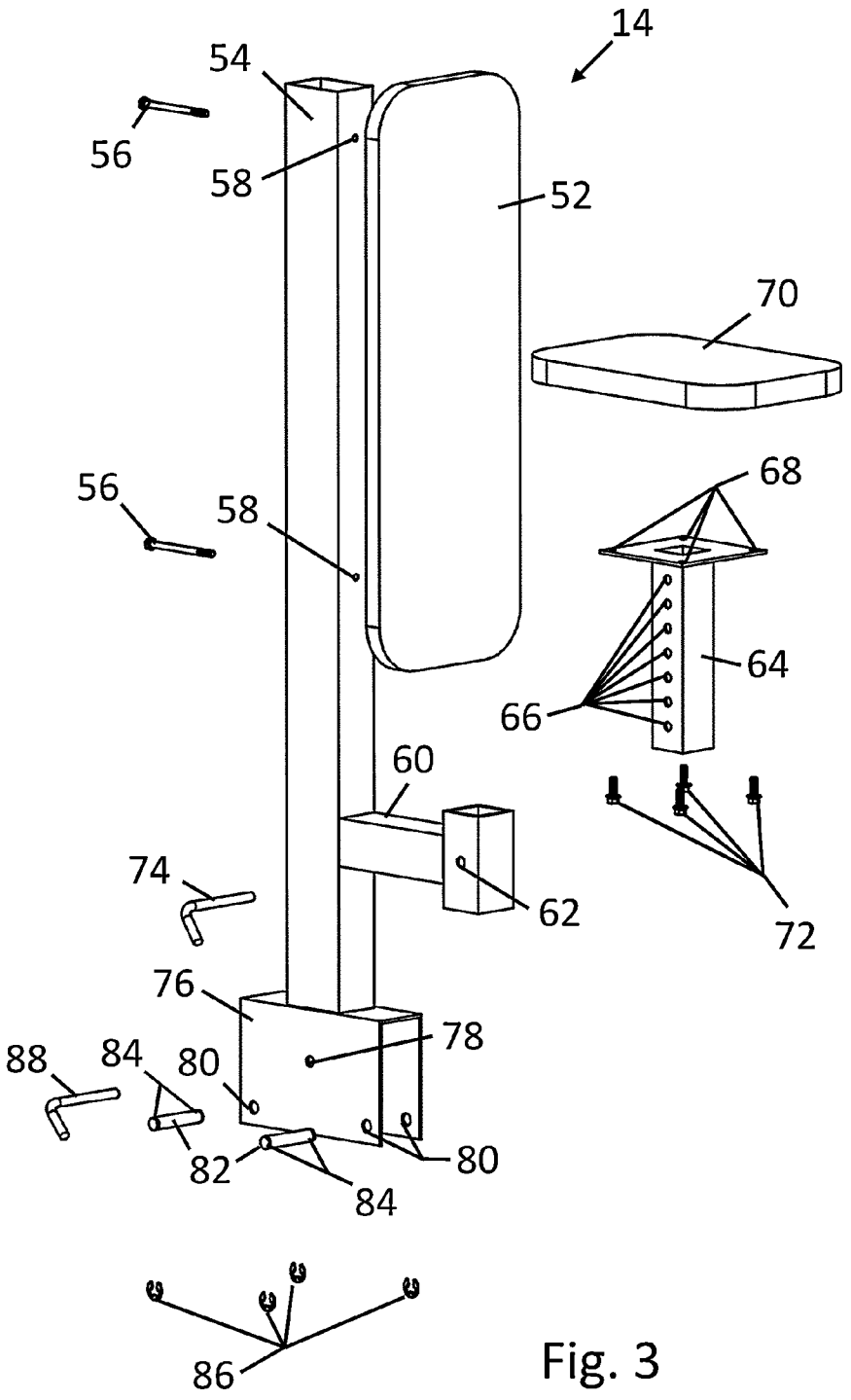


Fig. 3

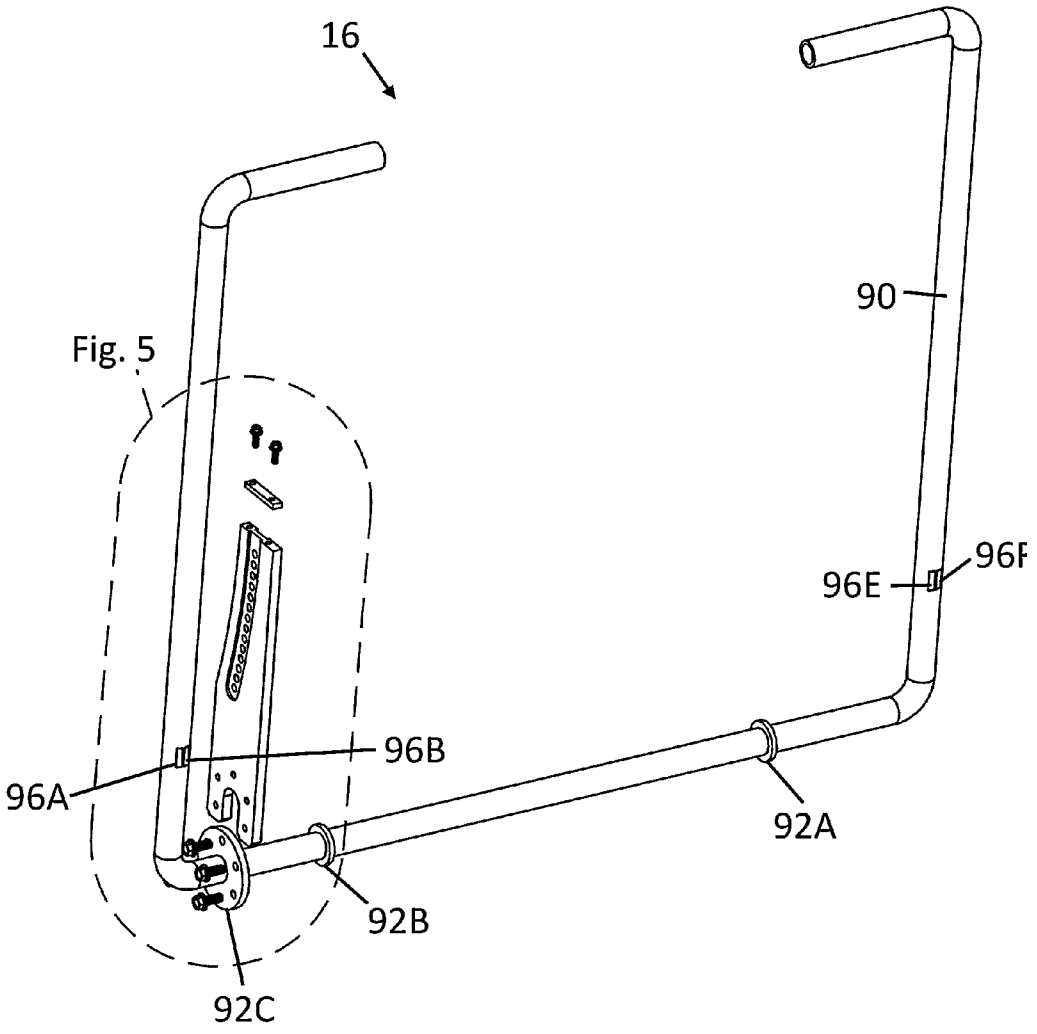


Fig. 4

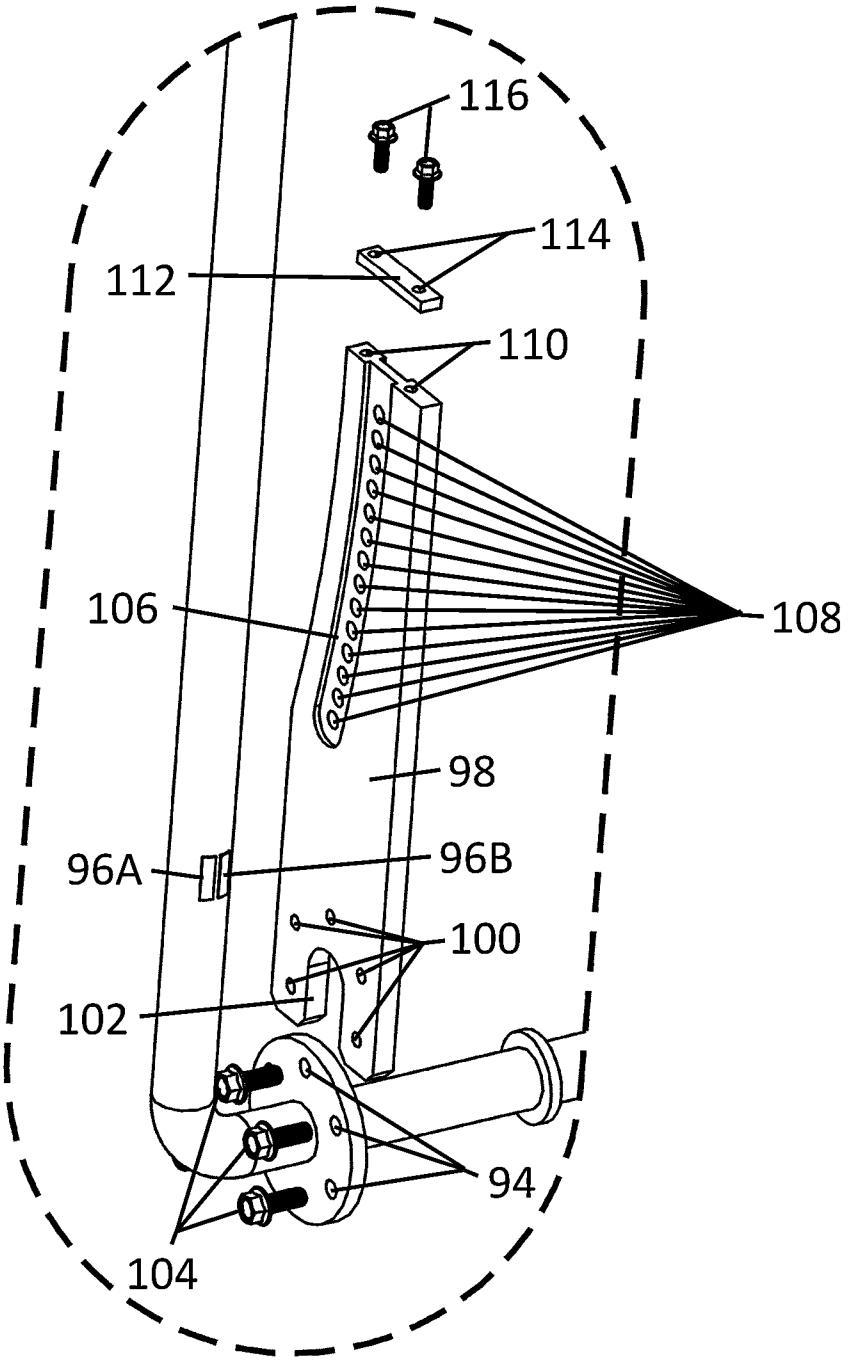


Fig. 5

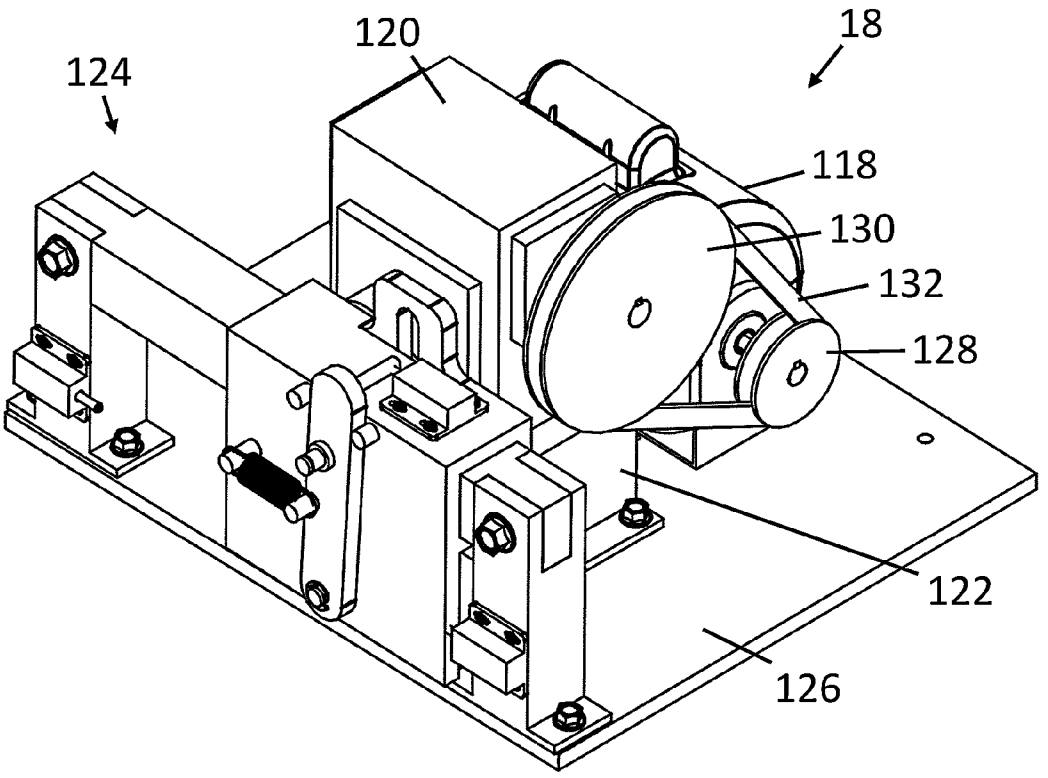
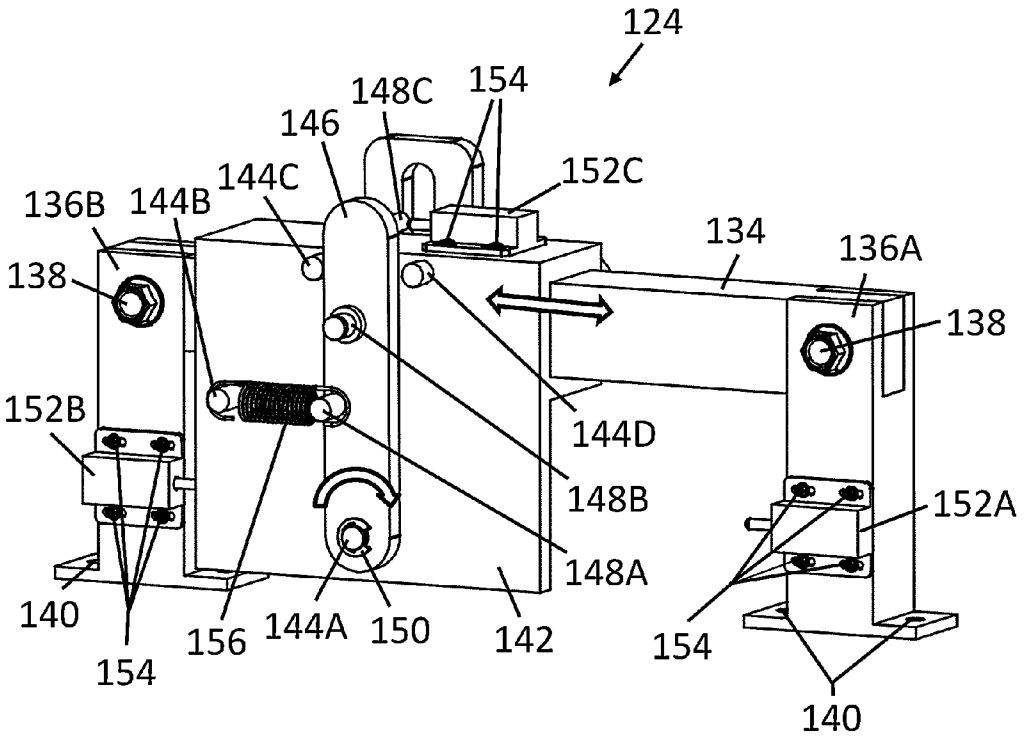


Fig. 6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148C
154
146
152C
144C
136B
144B
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140
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154
140

Fig. 7

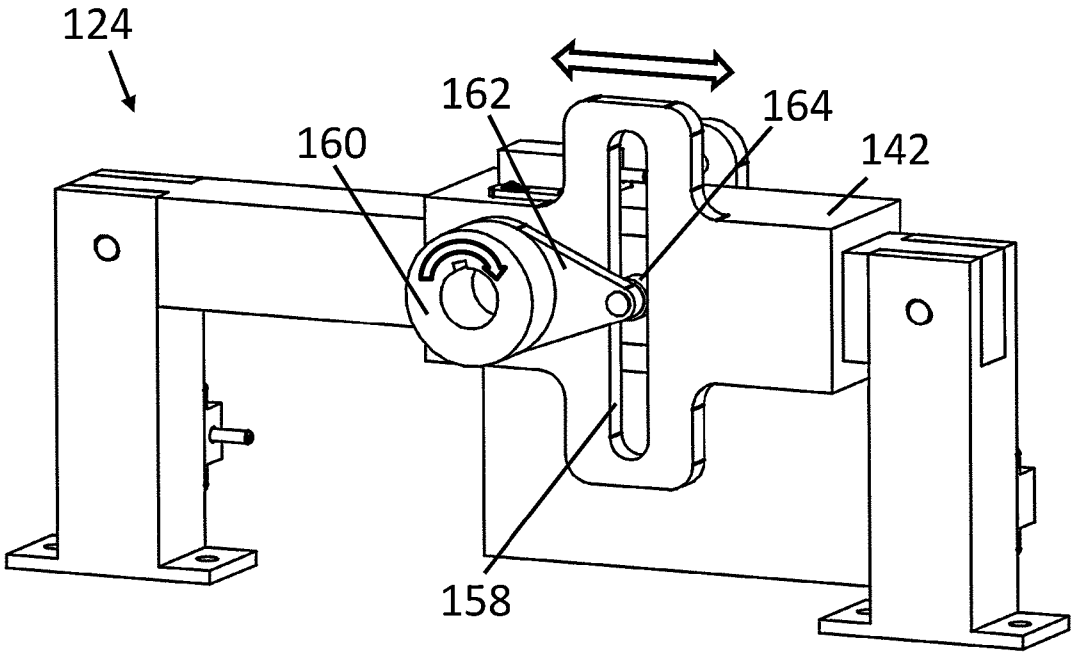


Fig. 8

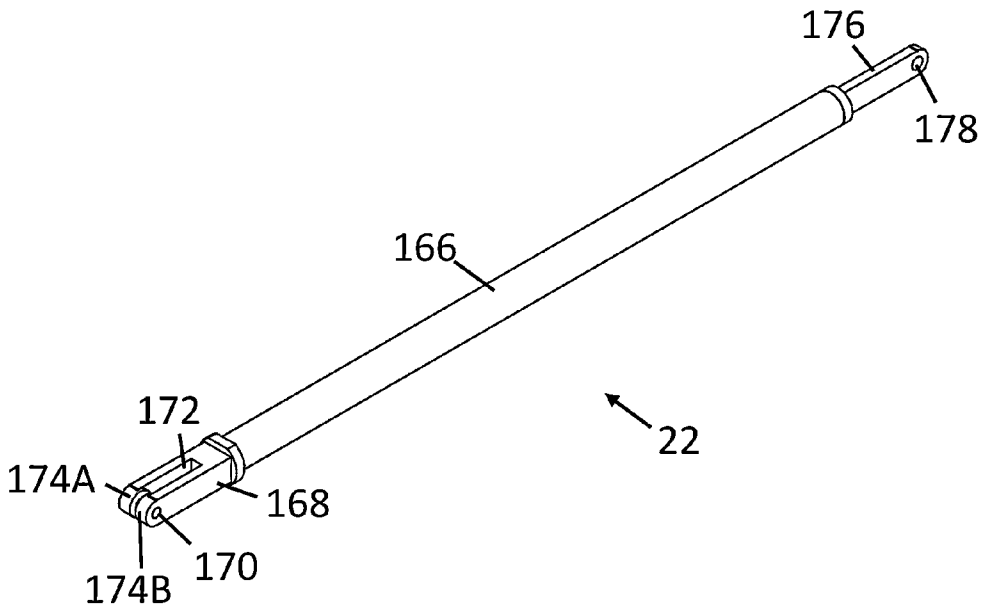


Fig. 9

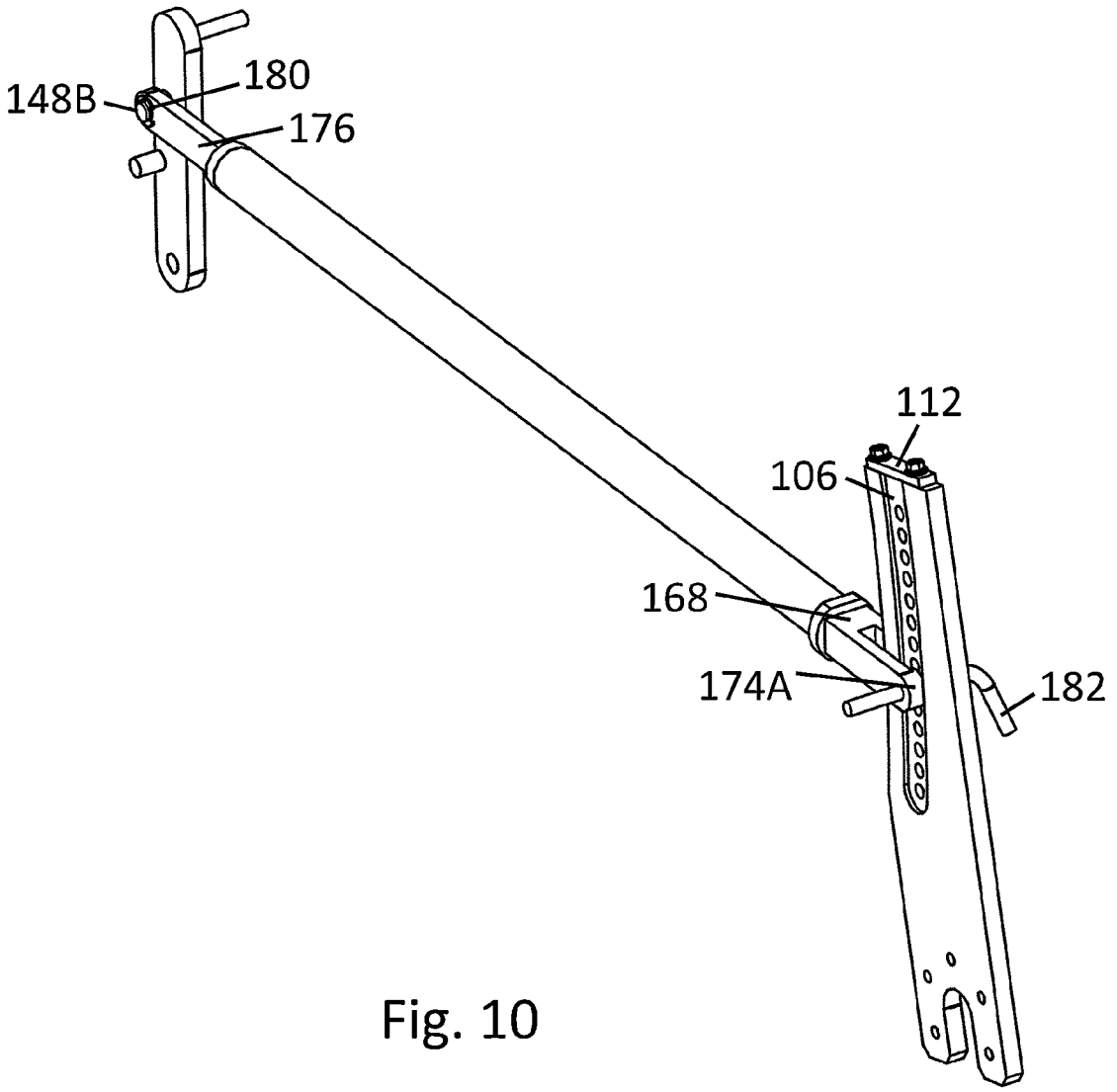


Fig. 10

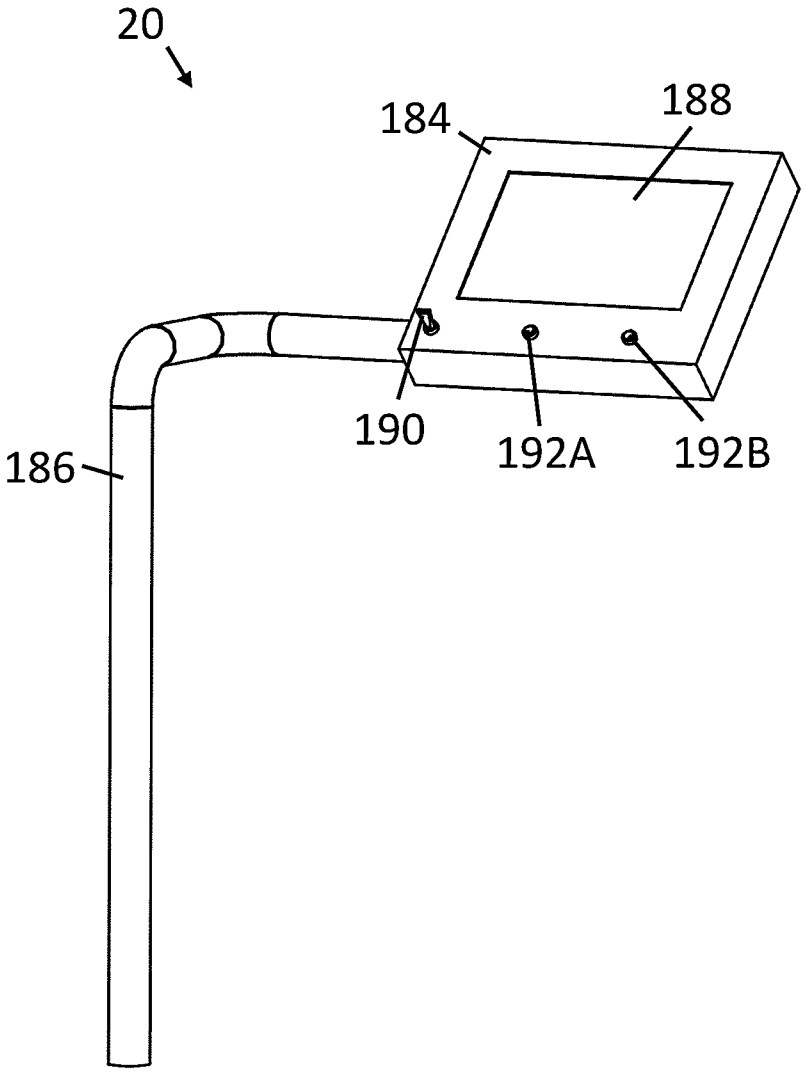


Fig. 11

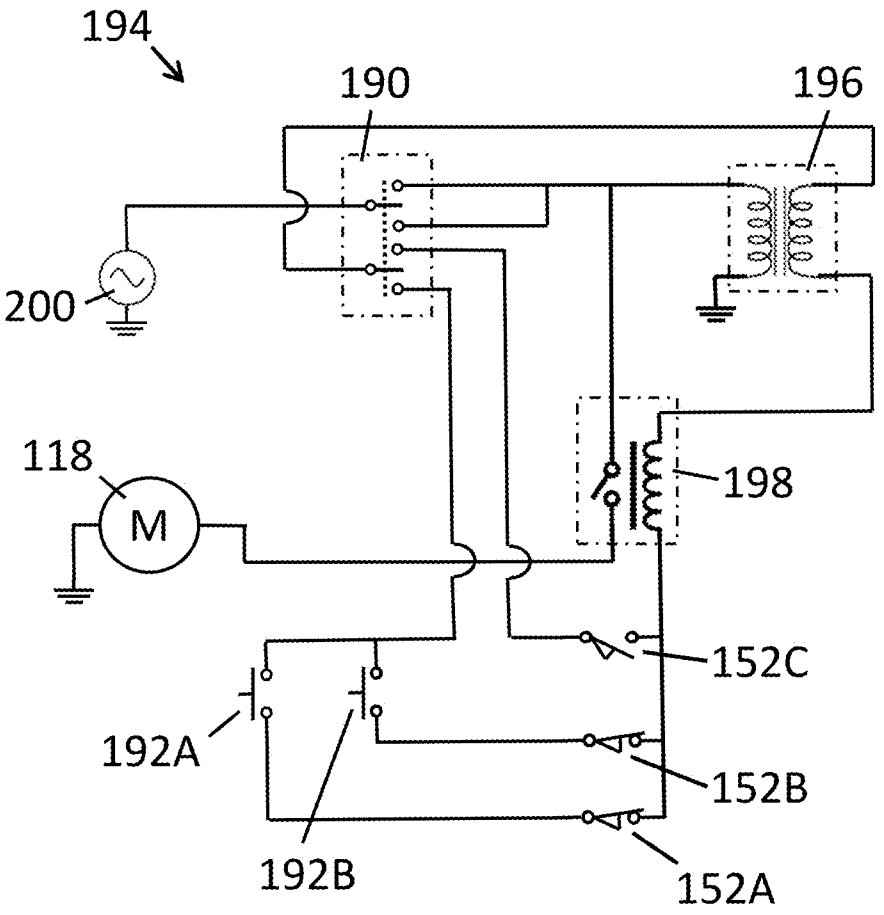
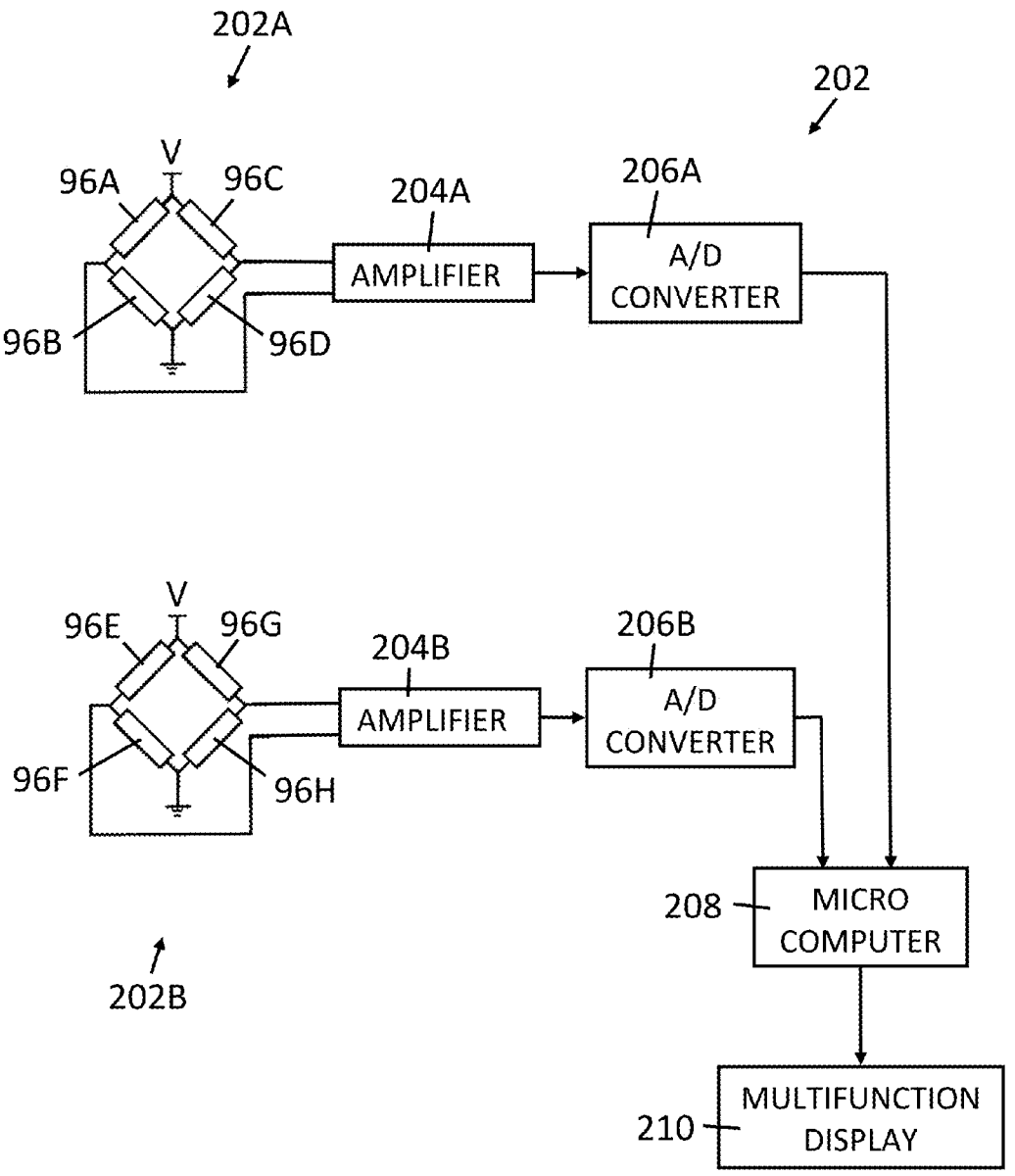


Fig. 12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202
V
96A
96C
204A
206A
AMPLIFIER
A/D CONVERTER
96B
96D
V
96E
96G
204B
206B
AMPLIFIER
A/D CONVERTER
96F
96H
208
MICRO COMPUTER
202B
MULTIFUNCTION DISPLAY
210

Fig. 13

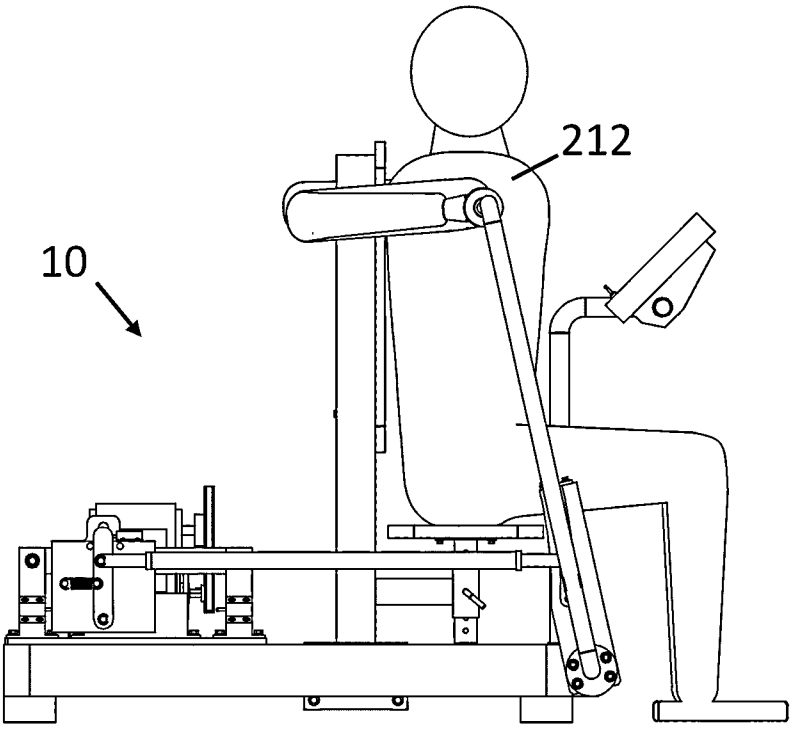

Fig. 14

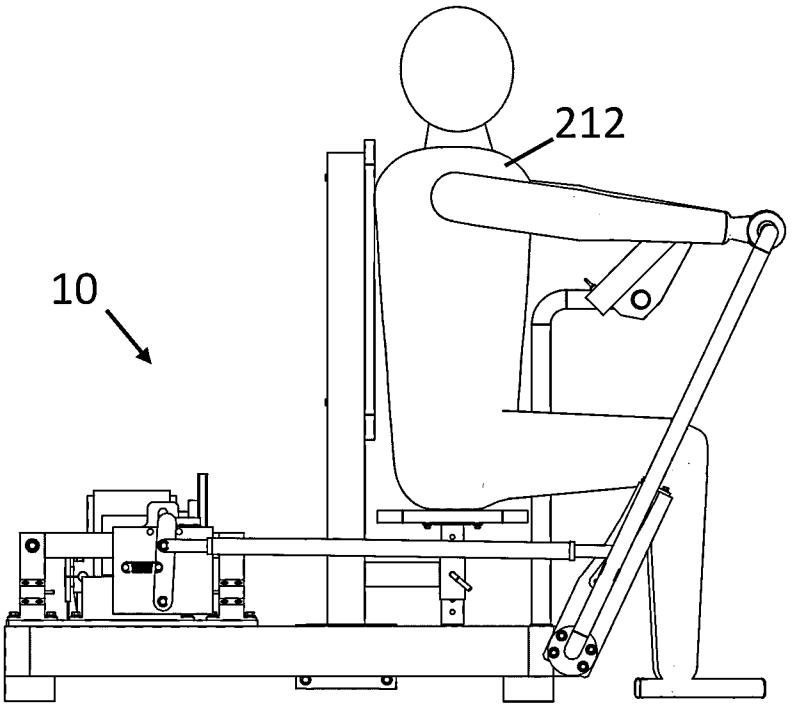

Fig. 15

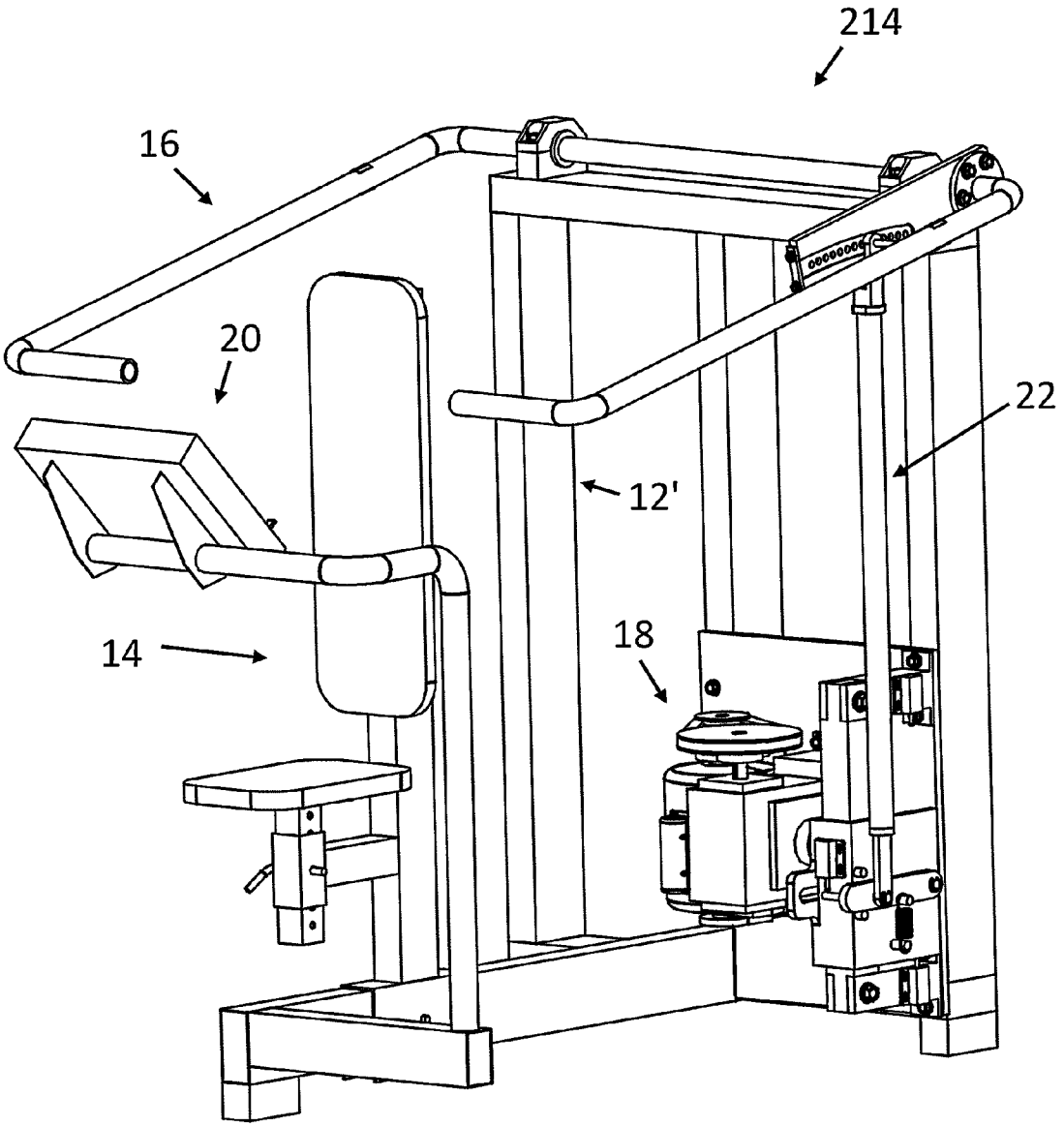

Fig. 16

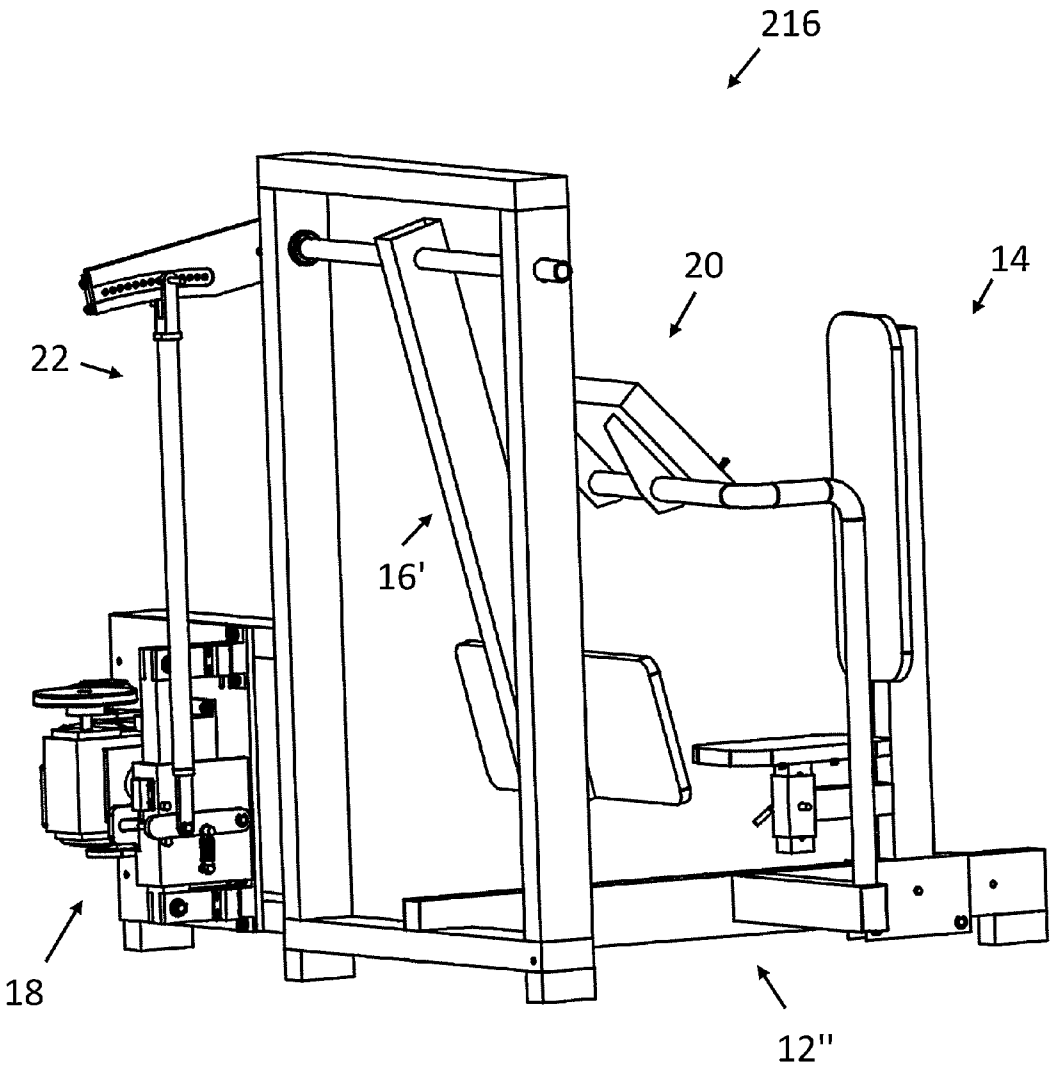

Fig. 17

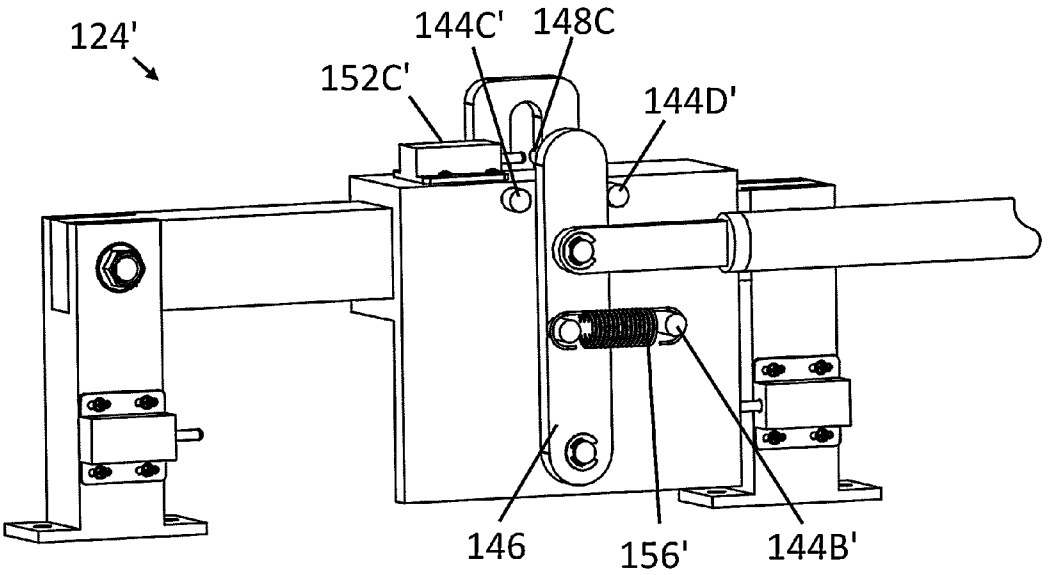

Fig. 18

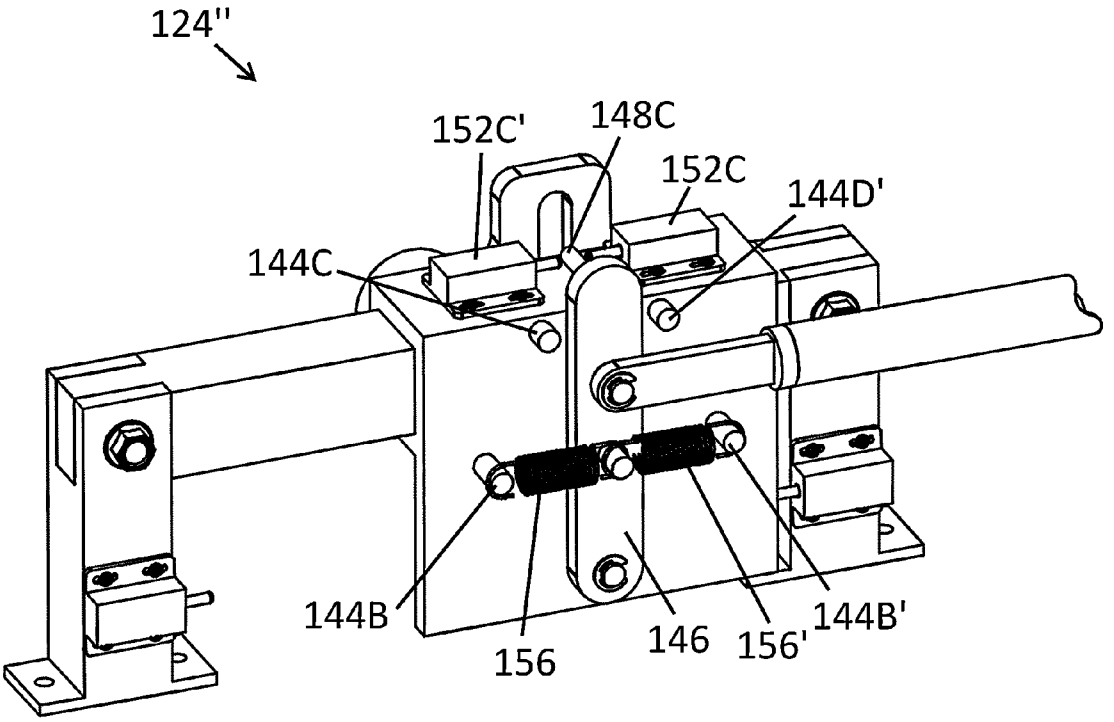

Fig. 19

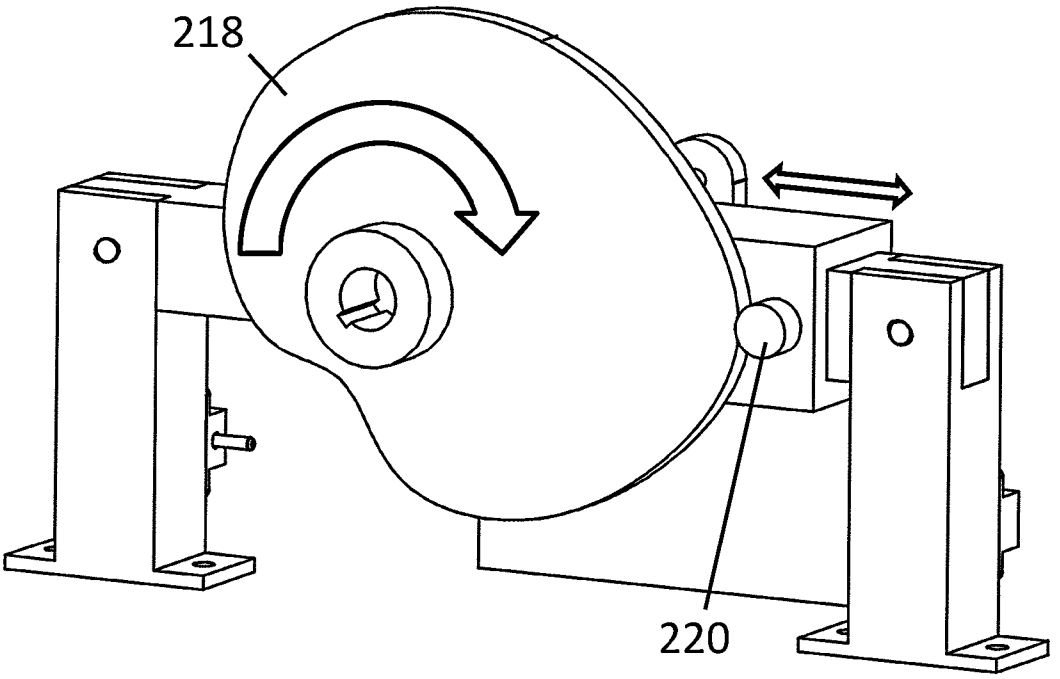

Fig. 20

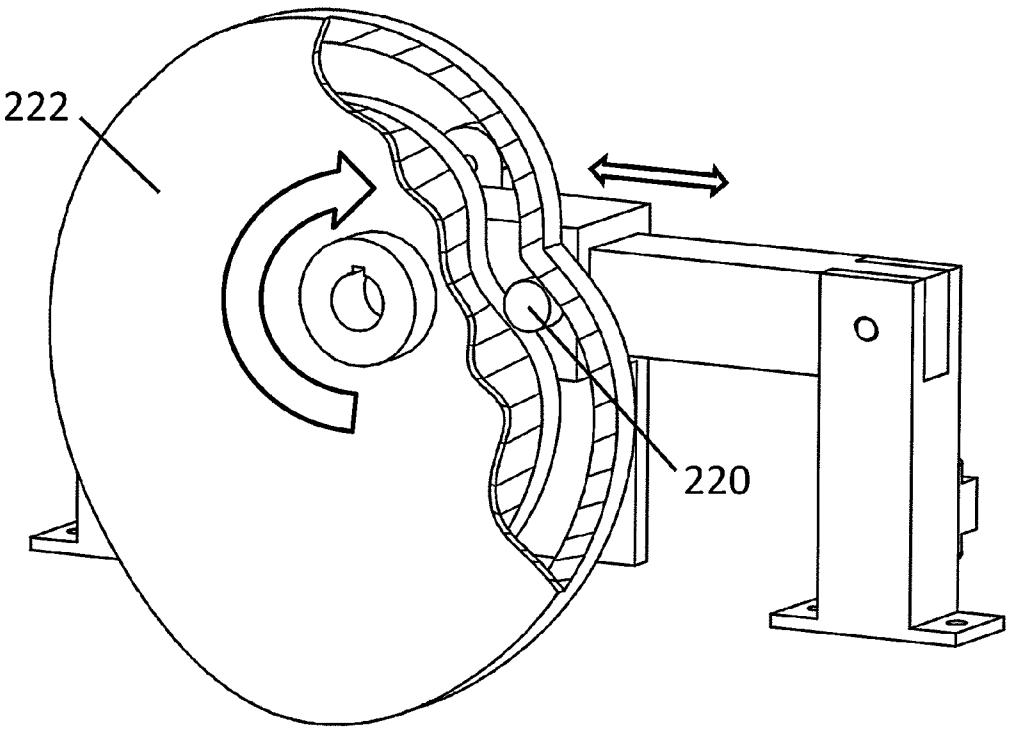

Fig. 21

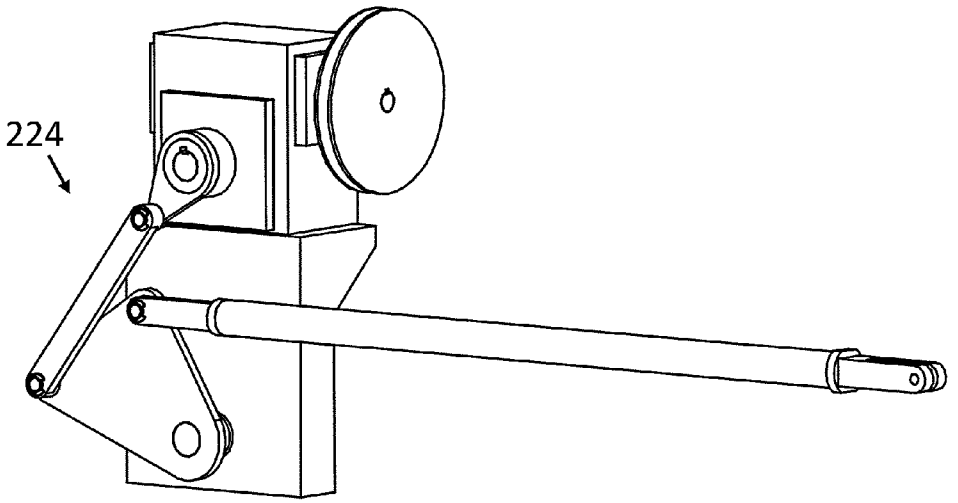

Fig. 22

EXERCISE MACHINE WITH CONTROLLED MOTION AND USER FORCE MATCHING RESISTANCE

BACKGROUND

Prior Art

[0001] Controlled movement exercise with user force matching resistance is recognized as a highly effective form of exercise since it allows the user to exert the maximum force he or she is capable of at each position throughout the full range of the exercise motion. It is also considered as among the safest forms of resistance exercise and is employed in machines used for physical therapy.

[0002] Despite these advantages, machines using controlled movement with user force matching resistance are rarely seen outside rehabilitation clinics due to their high cost, complexity and difficulty of adjustment and operation. Much of the complexity and cost comes from the motion and resistance controlling features themselves, as they include specialized electro-mechanical actuators, complex feedback features and often computer control in order to provide controlled movement resistance. Many make use of stepper or servo motors which in addition to being more expensive than a standard 120 volt single phase electric motor, have the additional expense of requiring a specialized power supply called an amplifier or driver.

[0003] Most of the prior art machines use some form of geared drive between the motor and the output arm. However, there have been some attempts made at producing a machine using a linkage between the motor and the output arm, but all have had shortcomings. U.S. Pat. No. 4,635,933 to Schnell (1987) shows one such attempt using a crank mechanism driven by an electric motor. However, the design specifies that the electric motor be a reversible variable speed/variable torque type motor, which will require a control circuit to control the motor thereby adding to the expense of the machine. The means of adjusting the output stroke shown, simply changing the length of the crank or rocker arms, will simultaneously change the starting and ending points of the exercise stroke, likely causing the user to have to change position. The starting and stopping of the machine is in control of the user and is performed by an action of a body part, such as a hand or foot, which is not being exercised.

[0004] U.S. Pat. No. 4,884,801 to Schnell (1989) shows another device using a flexible transmission member attached to a motor-driven crank to a user-actuated member. However, this device requires that the user activate the motor by the separate act of activating a switch either by hand or foot. There is also no provision to have the motor-driven crank stop or start in any particular position to allow for ease of adjustment or having a definite starting point to begin the exercise. Also, removal of the user force does not stop the motor. Furthermore, the stroke adjustment means shown will simultaneously change the starting and ending points of the exercise stroke, likely causing the user to have to change position.

Advantages

[0005] Accordingly several advantages of one or more aspects are as follows: to provide an exercise device with controlled motion and user force matching resistance in which the motion and resistance features are driven by a standard 120 volt single phase electric motor, which supplies resistance in response to force generated by the user regardless of magnitude or fluctuation, which starts automatically on application of user force and stops automatically on removal of user force, which allows the user to perform both concentric and eccentric contractions, which does not require feedback or computer controls to provide resistance and maintain velocity, in which forced concentric contractions and eccentric contractions may be safely performed without a spotter, in which eccentric contractions only training is possible without a spotter, and which is simple for the user to adjust and operate. Other advantages of one or more aspects will be apparent from a consideration of the drawings and ensuing description.

DRAWINGS

Figures

[0006] FIG. **1** shows a perspective view of an exercise machine in accordance with a first embodiment.

[0007] FIG. **2** shows a perspective view of the frame subassembly from the first embodiment.

[0008] FIG. **3** shows an exploded view of the adjustable seat subassembly from the first embodiment.

[0009] FIG. **4** shows an exploded view of the exercise arm subassembly from the first embodiment.

[0010] FIG. **5** shows an exploded detail view from FIG. **4**.

[0011] FIG. **6** shows a perspective view of the reciprocating drive from the first embodiment.

[0012] FIG. **7** shows a perspective view of the reciprocating mechanism from the first embodiment.

[0013] FIG. **8** shows a rear perspective view of the reciprocating mechanism from the first embodiment.

[0014] FIG. **9** shows a perspective view of the connecting rod subassembly from the first embodiment.

[0015] FIG. **10** shows the connecting rod subassembly connections from the first embodiment.

[0016] FIG. **11** shows a perspective view of the control panel subassembly from the first embodiment.

[0017] FIG. **12** shows an electrical schematic of the operating circuit from the first embodiment.

[0018] FIG. **13** shows a block diagram detailing force measured and displayed from the first embodiment.

[0019] FIG. **14** shows the user seated in the exercise machine from the first embodiment with the exercise arm in the fully contracted position.

[0020] FIG. **15** shows the user seated in the exercise machine from the first embodiment with the exercise arm in the fully extended position.

[0021] FIG. **16** shows a perspective view of an exercise machine in accordance with a second embodiment.

[0022] FIG. **17** shows a perspective view of an exercise machine in accordance with a third embodiment.

[0023] FIG. **18** shows a perspective view of a reciprocating mechanism in accordance with a second embodiment.

[0024] FIG. **19** shows a perspective view of a reciprocating mechanism in accordance with a third embodiment.

[0025] FIG. **20** shows a perspective view of a reciprocating mechanism in accordance with a fourth embodiment.

[0026] FIG. **21** shows a perspective view of a reciprocating mechanism in accordance with a fifth embodiment.

[0027] FIG. **22** shows a perspective view of a reciprocating mechanism in accordance with a sixth embodiment.

DETAILED DESCRIPTION

FIGS. 1 Through 15—First Embodiment

[0028] A first embodiment of the exercise machine, designated broadly as **10**, is illustrated in FIG. **1**. In this embodiment machine **10** is configured to perform a chest press exercise. Machine **10** includes a base or frame subassembly **12** to which is slidably connected an adjustable user support or seat subassembly **14**. An exercise arm subassembly **16** is pivotally connected to frame **12**. A reciprocating drive subassembly **18** is fixedly connected to frame **12**. A control panel subassembly **20** is pivotally connected to frame **12**. The output of drive subassembly **18** is connected to arm subassembly **16** by a link or connecting rod subassembly **22**. These components are described in detail below.

[0029] Referring to FIG. **2**, frame **12** includes a group of longitudinal frame members **24**A, **24**B and **24**C. Member **24**B includes a series of holes **26**. Holes **26** extend through both vertical faces of member **24**B, and are used in adjusting the longitudinal position of seat subassembly **14**. Members **24**A, **24**B and **24**C are rigidly and fixedly connected to a transverse frame member **28**A and a transverse frame member **28**B. A group of threaded holes **30** through the top horizontal faces of members **24**A, **24**B and **28**B are used to attach drive subassembly **18** to frame **12**. These assembled members are held off the floor by a group of feet **32**. A threaded hole **34** is located at two places on the front vertical face of member **28**A. Holes **34** are used to attach a pair of split bearing assemblies **36**. Each bearing subassembly **36** includes a bearing base section **38** having a set of through holes **40** and a bearing top section **42** having a set of through holes **44**. Both base section **38** and bearing top **42** have a half-cylindrical cut bearing surface **46**. A set of bolts **48** pass through holes **44** in bearing top **42**, holes **40** in base section **38** and into holes **34**, securing bearing assemblies **36** to member **28**A.

[0030] FIG. **3** shows details of seat subassembly **14** which includes a back rest **52** connected to an upright column **54** using a set of bolts **56** through a group of holes **58** into threaded holes (not shown) in the rear face of back rest **52**. A seat holder bracket **60** is fixedly connected to the lower portion of column **54**. Bracket **60** includes a hole **62** that extends through both sides of bracket **60**. A seat adjustment bar **64** containing a group of adjustment holes **66** extending through both vertical side faces and a group of holes **68** in the top surface, is fixedly connected to the underside of a seat bottom **70** by a set of bolts **72** which go through holes **68** into a group of threaded holes (not shown) in the bottom face of seat bottom **70**. A seat adjustment pin **74** extends through hole **62** in bracket **60** and one of holes **66** in bar **64**. A carriage **76** is fixed to the bottom of column **54**. Carriage **76** has a hole **78** extending through both sides of carriage **76** and a set of holes **80** extending through both sides of carriage **76**. A pair of rods **82** extends through holes **80**. Rods **82** have a groove **84** at each end. An e-clip **86** fits into groove **84** at each end to hold rods **82** in carriage **76**. Carriage **76** is slidably mounted on member **24**B. Downward and sideways motion of carriage **76** is prevented by the body of carriage **76**, while upward motion is prevented by rods **82**. Carriage **76**, and thereby seat subassembly **14**, can slide along the length of member **24**B. To secure the position of seat subassembly **14**, a pin **88** is inserted through hole **78** in carriage **76** and into one of holes **26** in member **24**B.

[0031] Referring to FIGS. **4-5**, arm subassembly **16** includes an arm tube **90** having a lower horizontal section, two vertical sections and two collinear upper horizontal sections separated by a gap. A group of flanges **92**A, **92**B and **92**C are fixedly attached to the lower horizontal section of tube **90**. Flange **92**C has a series of through holes **94** laid out in a circular pattern. A pair of strain gauges **96**A and **96**B is mounted on the front surface of one vertical section of tube **90**. A second pair of strain gauges **96**C and **96**D (not shown) is mounted directly behind the first pair on the rear surface of the same vertical section of tube **90**. A pair of strain gauges **96**E and **96**F is mounted on the front surface of the opposite vertical section of tube **90**. A second pair of strain gauges **96**G and **96**H (not shown) is mounted directly behind the first pair on the rear surface of the same vertical section of tube **90**. An adjustment plate **98** has a series of tapped holes **100** laid out in a circular pattern, and a cutout **102** which allows it to fit over the lower horizontal section of tube **90**. Plate **98** is attached to flange **92**C using bolts **104**. Plate **98** has a circular arc shaped channel **106** with a series of through holes **108** running along the center of the channel, and tapped holes **110** in the top surface. A cap **112** has a pair of through holes **114** and is mounted to the top of plate **98** with a pair of bolts **116**.

[0032] Referring to FIG. **6**, drive subassembly **18** includes an electric motor **118**, a speed reducer **120**, a stand **122** and a reciprocating mechanism subassembly **124**. Speed reducer **120** is mounted to stand **122** using bolts (not shown). Stand **122**, motor **118** and mechanism **124** are mounted on a base plate **126** using bolts partially shown. A drive pulley **128** is mounted on the output shaft of motor **118**. A driven pulley **130** is mounted on the input shaft of speed reducer **120**. Drive pulley **128** drives driven pulley **130** through a flexible belt **132**.

[0033] Referring to FIGS. **7** and **8**, mechanism **124** includes a guide rail **134**, supported by a front post **136**A and a rear post **136**B. Rail **134** is attached to post **136**A and post **136**B by a pair of bolts **138**. A set of through holes **140** in the bottom flange of post **136**A and post **136**B allow mechanism **124** to be attached to plate **126**. A carriage **142** is slidably fixed over rail **134**. The outside vertical face of carriage **142** includes a stud **144**A, a stud **144**B and stud **144**C. An activation lever **146** contains a stud **148**A, a stud **148**B and a stud **148**C. Lever **146** is pivotally mounted on stud **144**A and is held in place by an e-ring clip **150**. A limit switch **152**A is mounted to the outside face of post **136**A using a set of screws **154**. A limit switch **152**B is mounted to the outside face of post **136**B using screws **154**. A limit switch **152**C is mounted to the top face of rail **134** using screws **154**. An extension spring **156** is connected between stud **144**B and stud **148**A. The inside vertical face of carriage **142** contains a slot **158**. A hub **160** is connected to a crank arm **162** which has a cam roller **164** mounted to its end. Roller **164** rides in slot **158**. Hub **160** is mounted on the output shaft of reducer **120**.

[0034] Referring to FIG. **9**, rod subassembly **22** includes a tube **166** at the front end of which is connected a yoke **168**. Yoke **168** includes a through hole **170** and a slot **172**. A pair of cylindrical projections **174**A and **174**B are concentric to hole **174** and project a short distance past the inside faces of slot **172**. A flat end **176** is attached to the rear end of tube **166**. A through hole **178** is located at the rear end of end **176**.

[0035] FIG. **10** shows how the output of mechanism **124** is transmitted to arm subassembly **16** through rod subassembly **22**. Flat end **176** is pivotally mounted on stud **148**B and is secured in place by an e-clip **180**. Cylindrical Projections **174**A and **174**B ride in channel **106**. The location of yoke **168** along channel **106** is selected by a locating pin **182**. Referring

to FIG. **11**, control panel subassembly **20** includes a control box **184** which is mounted to a support tube **186**. Tube **186** is pivotally mounted on support stud **50**. Box **184** includes a display screen **188**, a three position DPDT control switch **190**, and a pair of normally open momentary push button switches **192**A and **192**B.

[0036] FIG. **12** shows a control circuit schematic **194** which controls the operation of machine **10**. Components of circuit **194** contained in box **184** include a transformer **196** and a low voltage relay **198**. Circuit **194** is supplied with a standard AC voltage source **200**. Transformer **196** steps down the supplied 120 VAC to a safe lower level. Relay **198** operates at the low voltage supplied by transformer **196** and is capable of switching the supplied 120 VAC. Components of circuit **194** external to box **184** include switch **190**, switches **192**A and **192**B, switches **152**A, **152**B and **152**C, and motor **118**.

[0037] Referring to FIG. **13**, a display output diagram **202** is shown which details the operation of the display. Diagram **202** includes components internal and external to box **184**. External components include strain gauges **96**A, **96**B, **96**C and **96**D, connected to form a whetstone bridge **202**A, and strain gauges **96**E, **96**F, **96**G and **96**H, connected to form a second whetstone bridge **202**B. A source of electrical potential V supplies the excitation voltage to bridges **202**A and **202**B. Internal components include a pair of amplifiers **204**A and **204**B, a pair of analog to digital converters **206**A and **206**B, a micro-processer **208** and a multifunction display **210**. The arrangement shown in FIG. **13** is well known in the art.

Operation

[0038] Referring now to FIGS. **1**, thru **15**, to use machine **10**, a user **212** first takes position in seat subassembly **14** as shown in FIG. **14**: seated on seat bottom **70** with his or her back against back rest **52**. Seat subassembly **14** acts as a positioning system to allow adjustment of the position of user **212** relative to the arm subassembly **16**. If control panel subassembly **20** is positioned in front of seat subassembly **14**, user **212** can rotate control panel subassembly **20** to one side to gain access to seat bottom **70**. Once seated, user **212** rotates control panel subassembly **20** to its position in front of seat subassembly **14**. To perform the exercise, user **212** first adjusts the position of seat subassembly **14** to suit user **212**'s seated shoulder height and reach. To begin these adjustments arm subassembly **16** should be in the fully contracted position, referred to as the initial position. If arm subassembly **16** is not already in this position, it may be moved there by placing control switch **190** into the adjustment mode position and pressing and holding switch **192**B. This action supplies low voltage DC power to relay **198**, which is activated and provides 120 VAC power to motor **118**. At this point drive subassembly **18** resumes its cycle at whatever point it stopped at previously, meaning that it may first cause arm subassembly **16** to move towards the fully extended position before moving towards the fully contracted position. Once arm subassembly **16** moves near its fully contracted position, carriage **142** contacts and activates limit switch **152**B, opening the circuit, removing power from relay **198**, which removes 120 VAC power from motor **118**. There will be some rotational inertia of motor **118** that will continue to move drive subassembly **18** and hence arm subassembly **16** slightly further. The activation point of limit switch **152**B can be adjusted to account for this additional motion, so that the final stopping point is as close to the fully contracted position as possible. Alternately an electromagnetic brake may be added to quickly stop motor **118**'s rotation.

[0039] Once arm subassembly **16** is in the fully contracted position, seat subassembly **14** adjustment can be achieved. User **212** adjusts the vertical position of seat subassembly **14** to a comfortable position to grasp upper horizontal portions of tube **90**. This will put user **212**'s shoulder joint generally even with the upper horizontal sections of tube **90**. This adjustment is accomplished by removing pin **74** from bracket **60**, moving seat bottom **70** and attached bar **64** up or down as required, and replacing pin **74** back through hole **62** in bracket **60** and hole **66** in bar **64** closest to the desired position. User **212** then adjusts the front to back position of seat subassembly **14** to a comfortable position to grasp upper horizontal sections of tube **90** as close to user **212**'s chest as is comfortable. This adjustment is accomplished by removing pin **88** from hole **78**, moving seat subassembly **14** to the rear or front as required, and replacing pin **88** through hole **78** in carriage **76** and hole **26** in member **24**B closest to the desired position. This type of adjustable seat is well known in the art.

[0040] The adjustments of seat subassembly **14** being completed, user **212** next adjusts the fully extended point of the stroke of arm subassembly **16**. With control switch **190** in the adjustment mode position user **212** presses and holds adjustment switch **192**A. This action supplies low voltage DC power to relay **198**, which is activated and provides 120 VAC power to motor **118**. At this point drive subassembly **18** resumes its cycle at whatever point it stopped at previously, meaning that it may first cause arm subassembly **16** to move towards the fully contracted position before moving towards the fully extended position. Once arm subassembly **16** moves near its fully extended position, carriage **142** contacts and activates limit switch **152**A, opening the circuit, removing power from relay **198**, which removes 120 VAC power from motor **118**. There will be some rotational inertia of motor **118** that will continue to move drive subassembly **18** and hence arm subassembly **16** slightly further. The activation point of limit switch **152**A can be adjusted to account for this additional motion, so that the final stopping point is as close to the fully extended position as possible. Alternately an electromagnetic brake may be added to quickly stop motor **118**'s rotation.

[0041] At this point user **212** adjusts the fully extended position of arm subassembly **16** to a comfortable position. Ideally this position will allow user **212**, with his or her back firmly against back rest **52** and applying considerable force against the upper horizontal sections of tube **90**, close to full extension of his or her arms without locking the elbows, as depicted in FIG. **15**. This adjustment is accomplished by removing pin **182** from hole **170** and moving yoke **168** of rod subassembly **22** up or down in channel **106**. Moving yoke **168** up will move arm subassembly **16** towards user **212**, resulting in a shorter total stroke. Moving yoke **168** down will move arm subassembly **16** away from user **212**, resulting in a longer total stroke. Once the desired fully extended position of arm subassembly **16** is determined, pin **182** is reinserted into hole **170** in yoke **168** and hole **108** in plate **98** closest to the desired position. This adjustment of the fully extended position of arm subassembly **16** does not affect the fully contracted position of arm subassembly **16** thereby requiring no adjustments of seat subassembly **14**. This is because the pattern of adjustment holes **108** in plate **98** are located on an circular arc, the radius of which is equal to the distance between holes **178** and **170** of rod subassembly **22**, and the center of which is con-

centric with stud **148**B when arm subassembly **16** is in the fully contracted position. This means that once the initial seat adjustments are made, they do not need to be further adjusted for changes to the fully extended position of arm subassembly **16**. This design feature allows an alternative method of fully extended position adjustment. If user **212** has used machine **10** in the past and is familiar with the desired fully extended position of arm subassembly **16**, the fully extended position may be set while arm subassembly **16** is in the fully contracted position by removing pin **182** from hole **170** and moving yoke **168** of rod subassembly **22** up or down in channel **106** until hole **170** lines up with the pre-known hole **108** in channel **106**.

[0042] Once seat subassembly **14** and arm subassembly **16** are adjusted, user **212** could choose to follow the steps outlined above and return arm subassembly **16** to the start position prior to beginning the exercise, or user **212** could begin the exercise from the fully extended position of arm subassembly **16**. To begin the exercise, user **212** places control switch **190** into the ON position. With user **212**'s back against back rest **52**, user **212** then grasps the two collinear upper horizontal sections of arm subassembly **16** and pushes them away from the his or her body. Seat subassembly **14** acts as a buttress to counter the user force applied to arm subassembly **16** and keep user **212** in place. The force applied by user **212** creates tensile force in rod **22** which transmits the force to lever **146**. The force must be sufficient to overcome the preloaded tension in spring **156**. This pre-load is selected to provide a means to automatically shut off power to electric motor **118** and hence the motion of arm subassembly **16** once user **212** removes force from arm subassembly **16**, and to prevent inadvertent low force contact with arm subassembly **16** from starting the machine at an undesirable time. Once this initial force is overcome, rod subassembly **22** pulls lever **146** against stud **144**D. This movement forces stud **148**C into limit switch **152**C. This completes the circuit supplying low voltage DC to relay **198** which thereby supplies 120 VAC to electric motor **118**. This causes drive subassembly **18** to begin cycling through its motion, driving the stroke of arm subassembly **16**. Arm subassembly **16** will continue to cycle between the positions of FIGS. **14** and **15** as long as sufficient force is applied by user **212** to overcome the preloaded force in spring **156**. As a consequence user **212** can start out the exercise with his or her full strength and continue until user **212**'s strength is insufficient to overcome the pre-loaded tension in spring **156**. The power output of motor **118** is chosen so that the rotational speed of the motor **118** and reducer **120**, and hence the cycle speed of mechanism **124** do not vary significantly regardless of the force applied by user **212** to arm subassembly **16**. In addition, the cycle speed is chosen so that from the aspect of user **212**, the movement may be considered quasi-static, resulting in a natural reaction force generated by machine **10** through arm subassembly **16** that has the same magnitude but the opposite direction of the force applied by user **212**. User **212** may also chose to apply the minimum force necessary to overcome the pre-loaded tension in spring **156** during the movement of arm subassembly **16** towards the fully extended position, and then apply full available strength during the movement of arm subassembly **16** towards the fully contracted position. This would constitute an eccentric contractions only exercise; know commonly in resistance training as negatives. These eccentric only contractions can also be added at the end of a concentric/eccentric exercise once the muscles become too exhausted to perform concentric contractions. These eccentric only or eccentric only after exhaustion movements are normally performed with the aid of a spotter who supplies the needed additional force to perform the concentric contraction, while allowing user **212** to perform the eccentric portion.

FIGS. **16-17**

Alternate Embodiments

[0043] A second embodiment of the exercise machine, designated broadly as **214**, is illustrated in FIG. **16**. In this embodiment machine **214** is configured to perform a shoulder press exercise. As shown in FIG. **16**, machine **214** contains seat subassembly **14**, arm subassembly **16**, drive subassembly **18**, control panel subassembly **20** and connecting rod subassembly **22**. These subassemblies have the same form and function as in the first embodiment described above. The only substantial difference in form is in the frame subassembly, herein designated as **12'**. The frame members have been rearranged and additional members added to facilitate the different exercise movement.

[0044] A third embodiment of the exercise machine, designated broadly as **216**, is illustrated in FIG. **17**. In this embodiment machine **216** is configured to perform a leg press exercise. As shown in FIG. **17**, machine **216** contains seat subassembly **14**, drive subassembly **18**, control panel subassembly **20** and connecting rod subassembly **22**. These subassemblies have the same form and function as in the first embodiment described above. The only substantial differences in form are in the frame subassembly, herein designated as **12"**, and the arm subassembly, herein designated as **16'**. As in the second embodiment above, the frame members in the third embodiment have been rearranged and additional members added to facilitate the different exercise movement. The arm subassembly has been reconfigured to interact with the user's feet.

FIGS. **18-22**

Additional Embodiments

[0045] Additional embodiments of some subassemblies of the machine can provide additional capabilities. For example, in FIG. **18** studs **144**B, **144**C, and **144**D, switch **152**C and spring **156** in mechanism **124** are replaced with studs **144**B', **144**C', and **144**D', switch **152**C' and spring **156'**. Switch **152**C' is wired in circuit **194** just as switch **152**C is. With these changes, application of a compressive force on rod **22** rather than a tensile force on rod **22** will rotate lever **146** toward switch **152**C', forcing stud **148**C into switch **152**C' to activate circuit **194**. This embodiment of mechanism **124** is designated broadly by **124'** in FIG. **18**. If mechanism **124** in machine **214** is replaced with mechanism **124'** then machine **214** embodiment becomes a pull down exercise machine embodiment.

[0046] Similarly in machine **10** embodiment shown in FIG. **1**, if seat subassembly **14** is rotated 180 degrees about its vertical axis, and mechanism **124** is replaced with mechanism **124'**, machine **10** embodiment becomes a rowing exercise machine embodiment.

[0047] Additionally, mechanism **124** may be configured as shown in FIG. **19**. In this configuration studs **144**B and **144**C, switch **152**C and Spring **156** are combined with studs **144**B', and **144**D', switch **152**C' and spring **156'**. Lever **146** is balanced between the two pre-tensioned springs **156** and **156'**

such that rotation of lever **146** is resisted in both directions. Studs **144**C and **144**D' are positioned to allow sufficient movement of lever **146** in both directions so that full movement in one direction causes stud **148**C to activate switch **152**C while full movement in the opposite direction causes stud **148**C to activate switch **152**C'. Switch **152**C' is wired in parallel with switch **152**C so that activation of either switch **152**C or switch **152**C' will activate circuit **194**. This embodiment of mechanism **124** is designated broadly by **124"** in FIG. **19**. If mechanism **124** is replaced with mechanism **124"** in machine **10**, then machine **10** becomes a combination chest press and rowing machine. If mechanism **124** is replaced with mechanism **124"** in machine **214**, then machine **214** becomes a combination shoulder press and pull down machine. Mechanism **124** in FIGS. **7** and **8** may be modified to include a cam **218** and a follower **220** as shown in FIG. **20**, a face cam **222** and follower **220** as shown in FIG. **21**, or a six bar linkage **224** as shown in FIG. **22**.

CONCLUSION, RAMIFICATIONS AND SCOPE

[0048] Accordingly, the reader will see that the exercise machines of the various embodiments will provide exercise for the user that has both controlled motion that does not vary significantly regardless of the force applied by the user, and supplies a resistance as a consequence of the natural reactive force that matches the force applied by the user, regardless of magnitude or fluctuation. Furthermore, the exercise machine has the additional advantages in that:

[0049] it is powered by a standard 120 volt single phase electric motor;

[0050] it starts automatically on application of user force and stops automatically on removal of user force;

[0051] it allows the user to perform both concentric and eccentric contractions;

[0052] it does not require feedback or computer controls to provide resistance and maintain velocity;

[0053] it allows forced concentric contractions and eccentric contractions may be safely performed without a spotter;

[0054] it allows eccentric contraction only training without a spotter;

[0055] it is simple for the user to adjust and operate.

[0056] While the above description contains many specificities, these should not be construed as limitations on the scope of the embodiments but as merely providing illustration of some of several embodiments. For example frame **12** may include additional members, certain components may be formed from multiple pieces, motor **118** may be directly connected to speed reducer **120**, or motor **118** may be integrated with speed reducer **120** forming a gearmotor. Thus the scope of the embodiments the should be determined by the appended claims and their legal equivalents, rather than by the examples given.

That which is claimed is:

1. An exercise machine, comprising in combination:

a frame;

an arm pivotally connected to said frame, configured to engage an exercising user;

a reciprocating drive means for driving said arm, said reciprocating drive means being fixedly mounted to said frame;

a rigid connecting means for connecting said arm and said reciprocating drive means so that movement of said reciprocating drive means causes said arm to move in response thereto, said arm being constrained thereby to move along a stroke path between a fully contracted position closest to said user, and a fully extended position furthest from said user, said fully contracted position being fixed and said fully extended position being adjustable; and

adjustment means for adjusting said fully extended position of said arm without changing said fully contracted position.

2. The exercise machine defined in claim **1**, wherein said user achieves exercise by applying force against said arm during movement of said arm along said stroke path.

3. The exercise machine defined in claim **1**, wherein said reciprocating drive means includes an electric motor operatively connected to a mechanical speed reducer which is operatively connected to a reciprocating mechanism, said reciprocating mechanism providing the output of said reciprocating drive means.

4. The exercise machine defined in claim **3**, wherein the output power of said electric motor is predetermined such that a generally constant rotational speed is maintained, generally irrespective of the force applied to said arm by said user.

5. The exercise machine defined in claim **3** wherein said reciprocating mechanism includes a mechanism selected from the group consisting of a scotch yoke mechanism, a cam and cam follower, a face cam and cam follower, and a six bar linkage.

6. The exercise machine defined in claim **1**, wherein said reciprocating drive means provides a predetermined generally equal duration of the extension and contraction strokes of said arm.

7. The exercise machine defined in claim **1**, wherein said reciprocating drive means provides a predetermined unequal duration of the extension and contraction strokes of said arm.

8. The exercise machine defined in claim **1**, wherein said reciprocating drive means is activated upon said user applying a predetermined force against said arm.

9. The exercise machine defined in claim **1**, wherein said reciprocating drive means is deactivated upon said user removing applied force against said arm.

10. The exercise machine defined in claim **1**, further including a bracing means for holding said user in a selected position relative to said arm and counteracting force exerted by said user upon said arm, said bracing means being slidably mounted to said frame, the position of said bracing means being adjustable in relation to said arm and fixable once desired position is reached.

11. The exercise machine defined in claim **1**, wherein a positioning means allows the user to activate said reciprocating drive means to move said arm to either said fully extended position and have it stop there or to said fully contracted position and have it stop there.

12. The exercise machine defined in claim **1**, wherein said adjustment means is comprised of a first attachment point of said rigid connecting means being pivotally connected to the output of said reciprocating drive means and a second attachment point of said rigid connecting means being slidably and pivotally connected to an element of said arm, said element having multiple attachment points laid out in a circular arc such that the radius of said circular arc is equal to the distance between said first attachment point of said rigid connecting means and said second attachment point of said rigid connecting means and the center point of said circular arc coincides with said connection between said first attachment point

of said rigid connecting means and said output of said reciprocating drive means when said arm is in said fully contracted position, wherein adjustment is achieved by changing said connection of said second attachment point of said rigid connecting means from the existing said attachment point of said element of said arm to a nonidentical attachment point of said element of said arm selected from said multiple attachment points on said element of said arm.

13. An exercise machine, comprising in combination:

a frame;

an arm pivotally connected to said frame, configured to engage an exercising user;

a reciprocating drive fixedly mounted to said frame, said drive including an electric motor operatively connected to a mechanical speed reducer the output of which is operatively connected a reciprocating mechanism, wherein said reciprocating mechanism provides the output of said reciprocating drive;

a rigid connecting rod having a first attachment point and a second attachment point separated by a predetermined distance for connecting the output of said reciprocating drive to said arm so that movement of said reciprocating drive causes said arm to move in response thereto, said arm being constrained thereby to move along a stroke path between a fully contracted position closest to said user, and a fully extended position furthest from said user, said fully contracted position being fixed and said fully extended position being adjustable;

a adjustment feature for adjusting said fully extended position of said arm without changing said fully contracted position, said adjustment feature comprising said first attachment point of said rigid connecting rod being pivotally connected to said output of said reciprocating drive and said second attachment point of said rigid connecting rod being slidably and pivotally connected to an element of said arm, said element having multiple attachment points laid out in a circular arc such that the radius of said circular arc equal to the distance between said first attachment point of said rigid connecting rod and said second attachment point of said rigid connecting rod and the center point of said circular arc coincides with said connection between said first attachment point of said rigid connecting rod and said output of said reciprocating drive when said arm is in said fully contracted position, wherein adjustment is achieved by changing said connection of said second attachment point of said rigid connecting rod from the existing said attachment point of said element of said arm to a nonidentical attachment point of said element of said arm selected from said multiple attachment points on said element of said arm; and

a seat slidably mounted to said frame for receiving said user and countering force applied to said arm by said user, said seat including a seat bottom for said user to sit upon and a backrest for supporting the back of said user, the position of said seat being adjustable in a generally horizontal plane in a direction generally perpendicular to the pivotal axis of said arm and said seat bottom being adjustable in a generally vertical plane, said position of said seat being fixable once desired position is reached.

14. The device defined in claim **13**, wherein the output power of said electric motor is predetermined such that a generally constant rotational speed is maintained, generally irrespective of the force applied to said arm by said user.

15. The device defined in claim **13** wherein said reciprocating mechanism includes a mechanism selected from the group consisting of a scotch yoke mechanism, a cam and cam follower, a face cam and cam follower, and a six bar linkage.

16. The device defined in claim **13**, wherein said reciprocating drive provides a predetermined generally equal duration of the extension and contraction strokes of said arm.

17. The exercise machine defined in claim **13**, wherein said reciprocating drive provides a predetermined unequal duration of the extension and contraction strokes of said arm.

18. An exercise machine, comprising in combination:

a frame;

an arm pivotally connected to said frame, configured to engage an exercising user;

a reciprocating drive means for driving said arm, said reciprocating drive means being fixedly mounted to said frame;

a rigid connecting means for connecting said arm and said reciprocating drive means by having a first attachment point connected to the output of said reciprocating drive and a second attachment point connected to an element of said arm, so that movement of said reciprocating drive means causes said arm to move in response thereto, said arm being constrained thereby to move along a stroke path between a fully contracted position closest to said user, and a fully extended position furthest from said user, said fully contracted position being fixed and said fully extended position being adjustable;

adjustment means for adjusting said fully extended position of said arm without changing said fully contracted position, said adjustment means comprising said first attachment point of said rigid connecting means being pivotally connected to said output of said reciprocating drive means and said second attachment point of said rigid connecting means being slidably and pivotally connected to an element of said arm, said element having multiple attachment points laid out in a circular arc such that the radius of said circular arc is equal to said distance between said first attachment point of said rigid connecting means and said second attachment point of said rigid connecting means, and the center point of said circular arc coincides with said connection of said first attachment point of said rigid connecting means to said output of said reciprocating drive means when said arm is in said fully contracted position, wherein adjustment is achieved by changing existing said connecting of said second attachment point of said rigid connecting means from the existing said attachment point of said element of said arm to a nonidentical attachment point of said element of said arm selected from said multiple attachment points on said element of said arm; and

a user support means for receiving said user and countering force applied to said arm by said user, said user support means being slidably mounted to said frame, the position of said user support means being adjustable in relation to said arm and fixable once desired position is reached.

19. The device defined in claim **18**, wherein said reciprocating drive means provides a predetermined generally equal duration of the extension and contraction strokes of said arm.

20. The exercise machine defined in claim **18**, wherein said reciprocating drive means provides a predetermined unequal duration of the extension and contraction strokes of said arm.

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